ANALOG GATE CIRCUITS FOR FAST TRIGGER APPLICATIONS

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Abstract

We have built a system of analog gates as a trigger for high energy physics experiments. The trigger is formed within 100 ns with TTL logic and could be sped up by use of ECL components. This trigger is ideal for eliminating a background of low energy cells from consideration in the trigger. At the same time the trigger can use fast information about the event to eliminate other backgrounds from the trigger.

Experiment Design

In a recent experiment (E751) at Brookhaven National Laboratory Multiparticle Spectrometer (MPS) a search for hyperon radiative decay required a trigger for a fast forward proton and a photon in a lead glass array. The fast forward proton was handled by a RAM trigger[1] and required that a photon decision be within 100 ns to be coincident. A tungsten target, 5 cm thick, was selected to absorb photons from the production vertices and thus enhance the photons from weak decays.

The photon detector was an array of lead glass of 129 blocks stacked in 10 rows in a staggered formation. The large blocks in rows 1,2,8,9, and 10 were SF5. 10cm × 10cm × 35cm. The other blocks were SF2, 9cm × 9cm × 33cm. The materials and sizes were chosen for availability. Each block had a 10 cm long, 6 cm radius lightpipe leading to an RCA4900 photmultiplier. The lightpipes were needed to allow the tubes to have magnetic shielding due to their proximity to the large magnetic field of the MPS. The lightpipes were made of the same glass as the block to increase acceptance of collected light.

In front of each row of lead glass was a single slat of scintillator to detect incoming charged tracks. This detector is labled H9 and was used to separate charged events from neutral hits in the lead glass. Charged pions from lambdas and other channels were a major background in the lead glass and needed to be separated by the trigger.

The monitoring system for the lead glass was a single LED which fed a bundle of optical fibers leading to each block in the array. The LED was pulsed by a microcomputer which also controlled a filter wheel to adjust the intensity of light going into the fibers. To monitor the trigger the microcomputer had to be able to select a single block, fire the LED for a different filter position and monitor the trigger turn on. This required a trigger that could have each channel associated with a block individually addressable.

Trigger Schemes

Two trigger schemes were considered to detect photons in the lead glass. The first was a simple row energy trigger which consisted of summing the phototube signals from one row of the detector and checking against a discriminator threshold equal to about 200 MeV. A coincidence of this discriminator and no signal from the corresponding H9 veto hodoscope constituted a successful photon hit.

This trigger was inadequate for three reasons. Photons near the threshold that split their energy between two rows would be missed. The tungsten target generated many soft photons under 10 MeV that would add to make a trigger if a lower threshold or larger region was included. And the need to monitor a block by block trigger led us to build an analog trigger scheme.

For the analog trigger the output of each block entered an analog gate with a threshold of about 75 MeV that remained closed if there was a signal in the H9 row in front of that block. The outputs of the analog gates were summed together and integrated. The integrated signal then went through a discriminator set for a 200 MeV threshold to generate a successful photon hit. To time the integrator each analog gate channel generated a gate pulse whose logical or activated the integrator. (Fig. 1).

The basic structure of the analog gate (fig. 2) was to take the incoming signal and split it, holding half in a lumped constant delay package. The other half of the signal would enter a comparator that could be disabled if the channel was vetoed. The output of the comparator would start a single pulse of a multivibrator with a width longer than any signals that would need to pass the gate. One output of the multivibrator went to a gate out to the integrator to enable it and the other output went to a transistor driver to open an FET transistor switch before the signal emerged from the LC delay. The signal from the LC delay then passed thrugh the FET switch for summation and integration.

For E751 eight channels were put on a board to fit in a double-width CAMAC crate. The front had lemo connections for signal in and out, plus a veto line from H9 and a single gate out to the integrator. The backplane was specially wired to carry an eight bit address and a strobe from the microcomputer to turn off all but the selected channel. The cost in 1982 was about $30 per channel including crates, bulkheads and other hardware interfacing.

Trigger Performance

The logic components for the analog gate were TTL to minimize heat and power. Even so the trigger worked with only a 75 ns delay. The timing across various components is shown in the following table.

COMPONENT	MODEL USED	RESPONSE TIME
Discriminator	NE521	15 ns
Multi-vibrator	74LS123	25 ns
Driver	2N3646	15 ns
FET switch	SD5000	10 ns
Analog gate total		65 ns
Integrator		15 ns

On a special trigger test with neither photon trigger active, but with the proton trigger, events were selected that had a photon from pattern recognition. These events were checked for trigger bits corresponding to the row energy and analog gate triggers. The graph (fig. 3) shows the ratio of failed triggers to total triggers for each trigger as a function of photon energy in 50 MeV bins.

The analog gate trigger outperformed the row energy trigger for all photon energies, failing primarily for photons that were in the same row as a charged track. The analog gates had a faster turn on at threshold due to the ability to pick up photons shared between two rows.

Further Uses

The response time of the analog gate can be sped up by using ECL based logic instead of TTL. Using 10K ECL2, a possible logic and timing are shown (fig. 4). This would make an analog gate fast enough to be used in the first level of SSC triggering.

An analog gate such as this would be useful as the first unit for calorimeter triggers. A low threshold would discriminate against frequent low energy deposition in a single element. Clusters of calorimeter cells could then be added to test for jets above a certain P± and the or of these hits would count total number of jets. A total transverse energy trigger could be made by summing all the analog signals over threshold without triggering on a large background.

References

1. E. D. Platner et al., "Programmable Combinational Logic System for High Energy Particle Physics Experiments," Nuclear Instruments and Methods **140**, 549 (1977).

2. See for instance Motorola MECL Data Book, Motorola Inc. 1982.

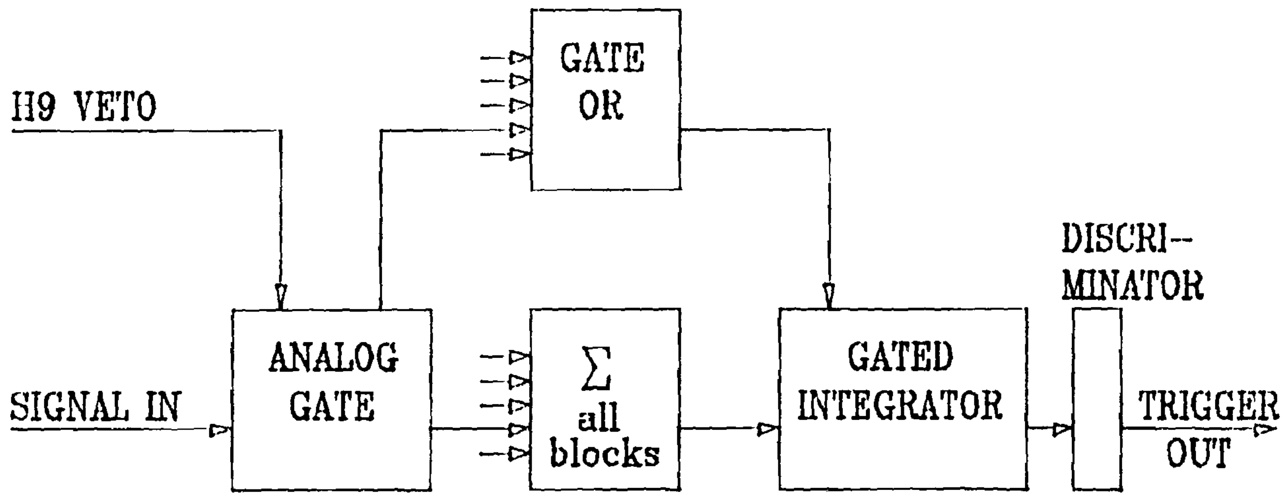


FIG. 1 ANALOG PHOTON TRIGGER

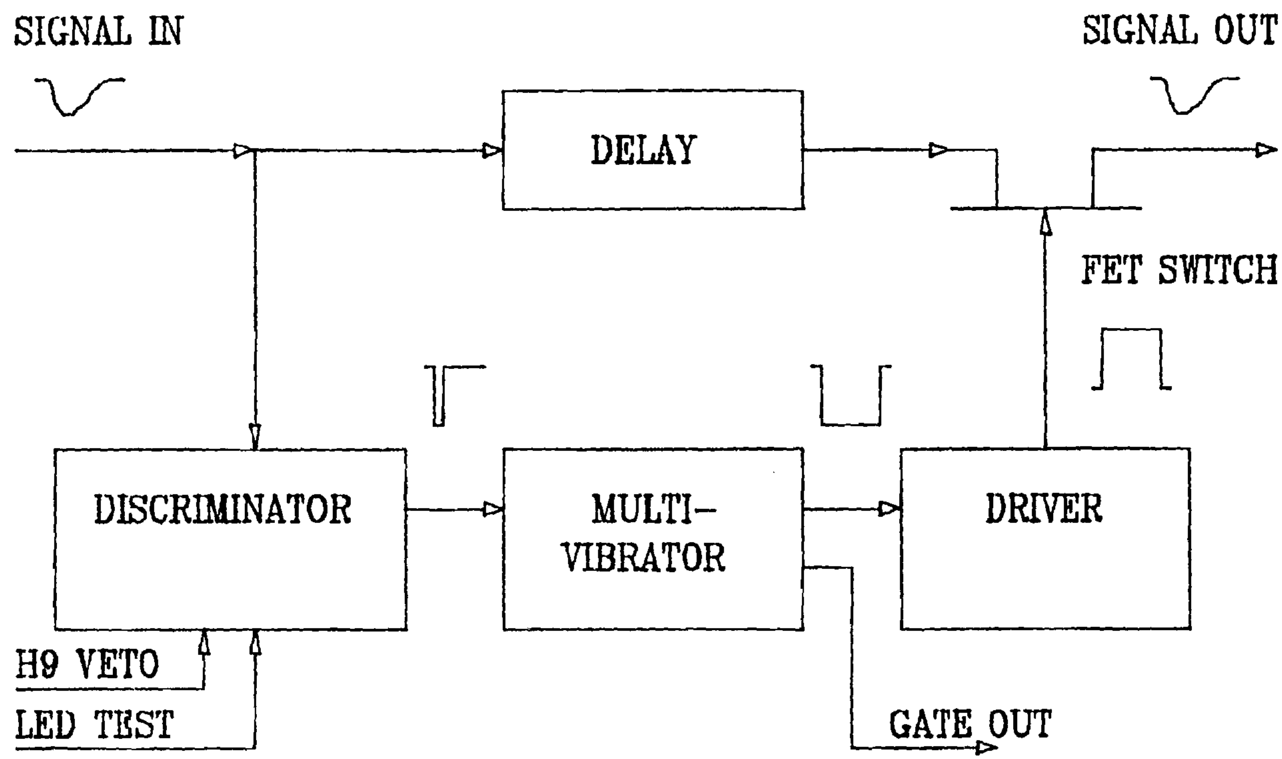
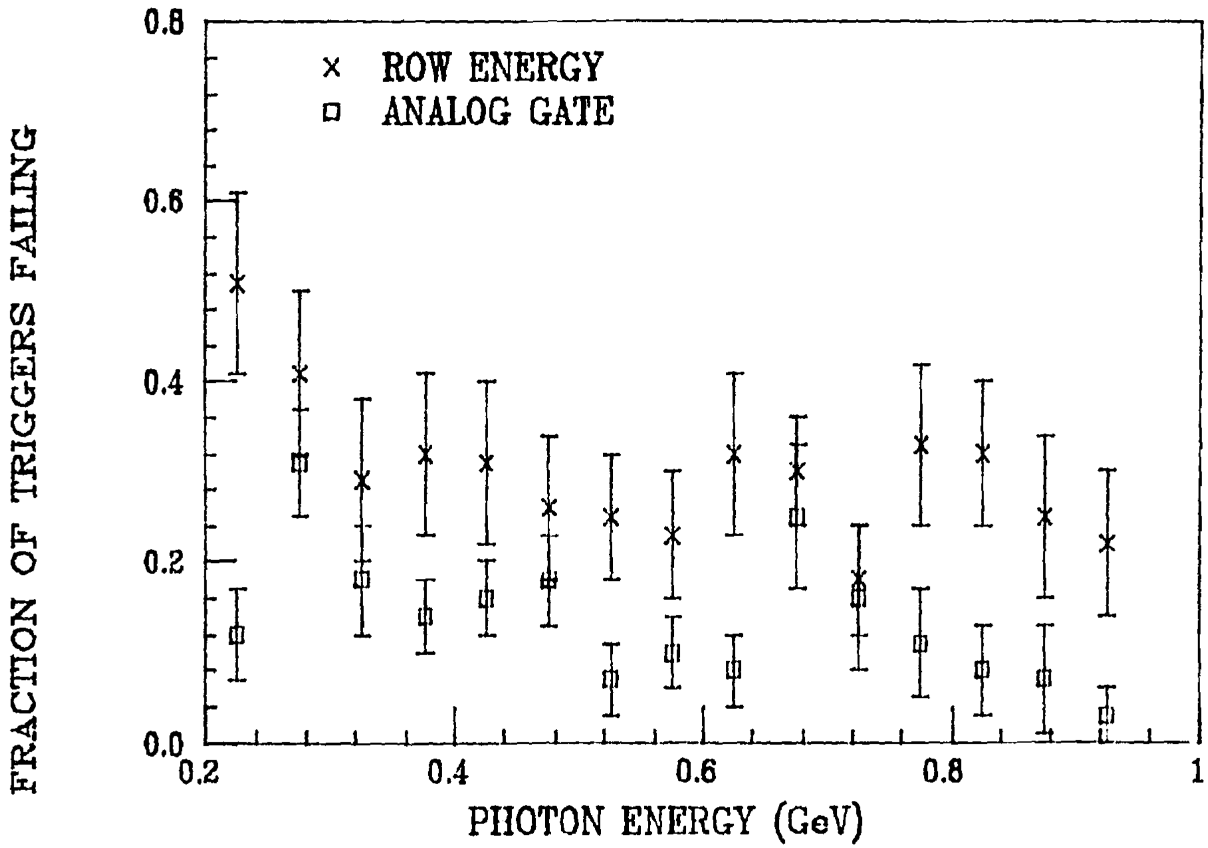


FIG. 2 ANALOG GATE LOGIC

FIG. 3 PHOTON TRIGGER PERFORMANCE



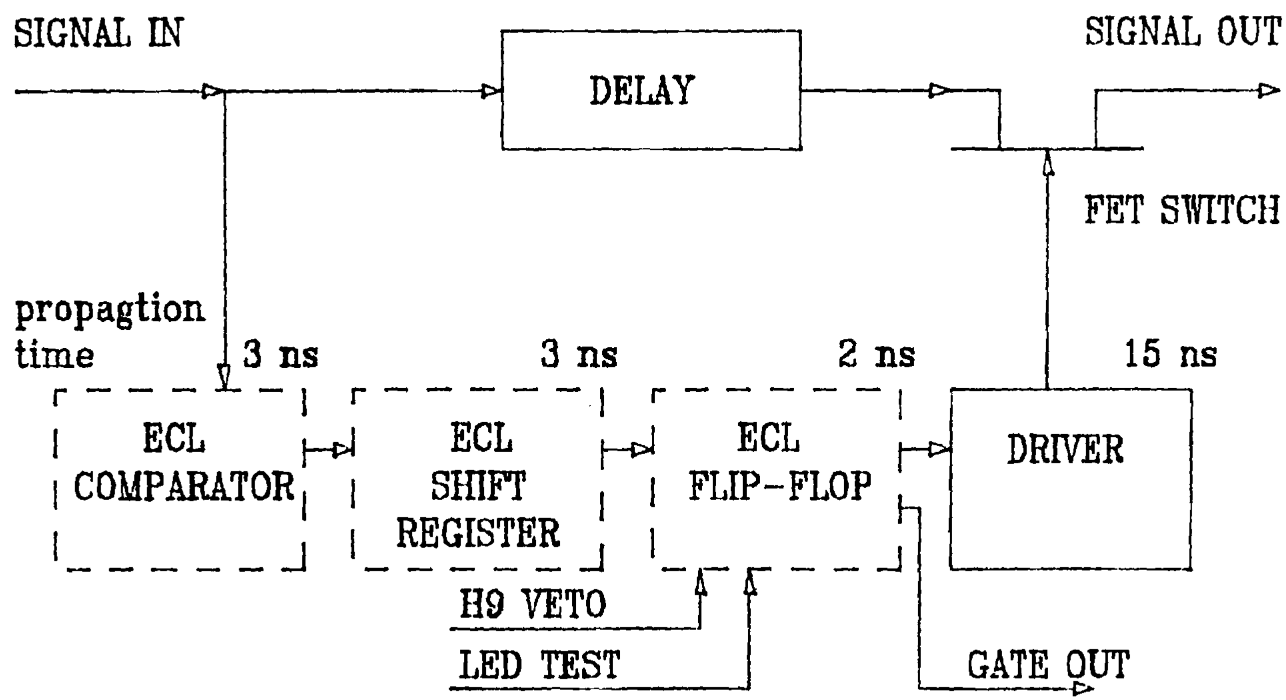


FIG. 4 ECL ANALOG GATE